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ZOOLOGY.—*A burrowing barnacle of the genus* Trypetesa (order Acrothoracica).[1]

Jack T. Tomlinson, Department of Zoology, University of California. (Communicated by Fenner A. Chace, Jr.)

A previously unreported acrothoracican barnacle has been found burrowing in *Tegula* shells occupied by hermit crabs in the intertidal zone of central California. A description and certain aspects of the life history of this form are given. A more detailed morphological study is in preparation for future publication.

Subclass Cirripedia (Lam.) Burmeister, 1834

Order Acrothoracica Gruvel, 1905

Diagnosis.—Boring cirripeds with soft mantle without calcareous plates; cirri reduced, concentrated toward posterior end of body, one pair in vicinity of mouth ("mouth cirri"), and widely separated from other pairs, remaining pairs 2, 3, or 4 in number. Three pairs of mouth appendages. Abdomen lacking (?). Hermaphroditic or sexes separate. Males dwarf. Ovaries in a more or less flattened part of mantle ("disk"), which serves at same time to anchor it in the hole. Development always includes a cypris stage, with a nauplius stage in most of the species studied. Live buried in chiton and barnacle plates, gastropod shells, and corals.

Suborder Apygophora Berndt, 1907

Diagnosis.—Sexes separate. Female: An external chitinous mantle "sack" more or less regularly rounded or oval serving to fix the animal in a burrow in a shell; one pair of biramous mouth cirri; three pairs of quadriarticulated and uniramous thoracic cirri, the first two pairs possessing small prickly pads on second articulation; two lateral folds on inside of mantle which are perhaps ovigerous frenae; alimentary canal a sacculated system without an anus; esophagus spineless; nervous system consists of brain and one ventral ganglion.

Rudimentary (dwarf) males: Small, fixed on upper part of disk of female or grouped on cavity in shell; in the form of an elongated bag, naked and transparent; with a small opening for passage of a well-developed probosciform penis; only eyes, testis, seminal vesicle, and penis are developed.

Cyprid larvae with six pairs of thoracic appendages biramous and natatory; abdominal segment with two large appendages.

Family Trypetesidae Kruger 1940 (=Alcippidae Gerstäcker, 1866; Gruvel, 1905).

With the characteristics of the suborder

Genus **Trypetesa** A. M. Norman, 1903

(=*Alcippe* Hancock, 1849; Darwin, 1854; Berndt, 1903, 1907; Genthe, 1905; Kuhnert, 1935; *Alcippoides* E. Strand, 1928. *Non Alcippe* Blyth, 1844.)

Trypetesa lampas (Hancock)

"Capitulum" laterally compressed, perpendicular to surface of the shell, with "disk" or ovigerous portion dorsoventrally compressed and

[1] This work was completed in partial satisfaction of the requirements for the degree of master of arts in zoology at the University of California, under the supervision of Dr. Willard D. Hartman, to whom I am indebted for encouragement and assistance.

parallel to surface of host shell; nauplius free-swimming; adult exceeding 8 mm; bilaterally symmetrical; male attached only to disk of female; reported from the sublittoral of the northern Atlantic Ocean and the Mediterranean Sea.

Trypetesa lateralis, n. sp.

Laterally compressed throughout; no free-swimming nauplius; adult does not exceed 5 mm; not bilaterally symmetrical in mantle structure (lips of mantle opening asymmetrical; with a large external flap on left side of mantle only); male attached to disk of female or to the cavity wall near the external flap; found in littoral zone of central California.

Diagnosis.—Female laterally compressed throughout and situated laterally to right of slit in host shell, relative to point of attachment; "horny knob" of disk relatively small, on a recognizable stalk or peduncle; size not in excess of 5 millimeters; flap on the left surface of the mantle extends in adult to external surface of host shell, which it minutely perforates; retains young to cyprid stage; body proper resembles that of *Trypetesa lampas*, but much smaller; mantle sac not bilaterally symmetrical (Fig. 1); males may be numerous and attached to horny disk or knob of female or grouped on wall of cavity near external mantle flap.

The species is named for the wholly laterally compressed body and the orientation of the animal within the shell, laterally from the aperture.

Type specimen.—U. S. National Museum no. 93450.

Type locality.—Moss Beach, San Mateo County, Calif.

Dimensions of type.—Maximum diameter, 3.2 mm; right lip length 1.1 mm; dimension "A" (see Fig. 7), 1.85 mm; dimension "B", 2.7 mm.

Repositories of other type material.—California Academy of Sciences, San Francisco, Calif., no. 9857; Allan Hancock Foundation, University of Southern California, Los Angeles, Calif.; University of California Museum of Paleontology, Berkeley, Calif., no. 32960.

Distribution.—Point Arena, Mendocino County, Calif., to Shell Beach, San Luis Obispo County, Calif. (search for it was made at intervals from San Juan Island, Wash. to Ensenada, Baja California, Mexico. See Fig. 5). Intertidal. In *Tegula* shells occupied by all species of *Pagurus* within the range (all were in shells of *Tegula brunnea* and *T. funebralis* except for 3 *Calliostoma costatum* and 1 *Acanthina spirata*. Hermit crabs: *Pagurus granosimanus*, *P. hemphillii*; *P. hirsutiusculus*, and *P. samuelis*). A significant preference in the total sample for *T. brunnea* shells and for those occupied by *P. samuelis*. (This latter preferred association may result from the fact that *P. samuelis* is more abundant at the higher levels of the intertidal region where the barnacle itself is more abundant.

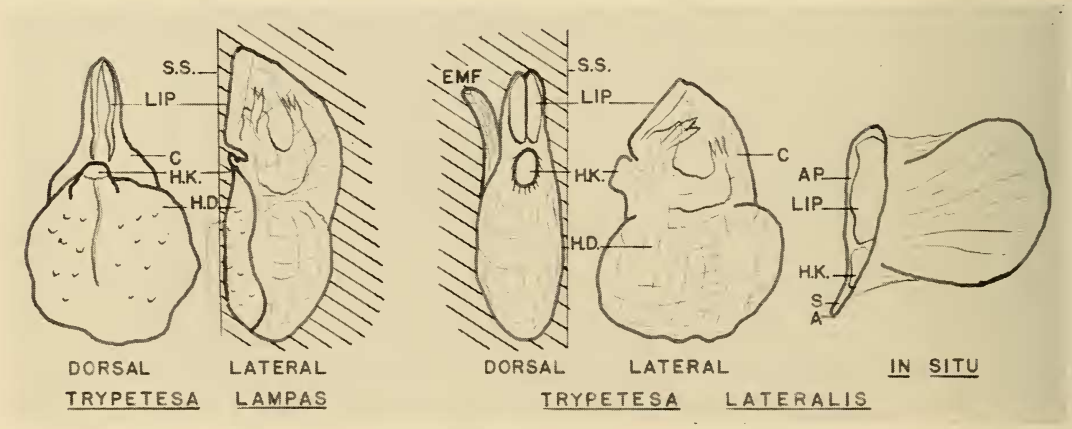

FIG. 1.—*Trypetesa lampas* (after Genthe) and *T. lateralis*.

ABBREVIATIONS USED IN FIG. 1

a—point of attachment.
ap—aperture of shell cavity.
c—capitulum.
e.m.f.—external mantle flap.
h.d.—horny disk.
h.k.—horny knob.
lip—lip or edge of mantle.
s.s.—shell surface (approx. relative position).
s.—slit (early aperture)

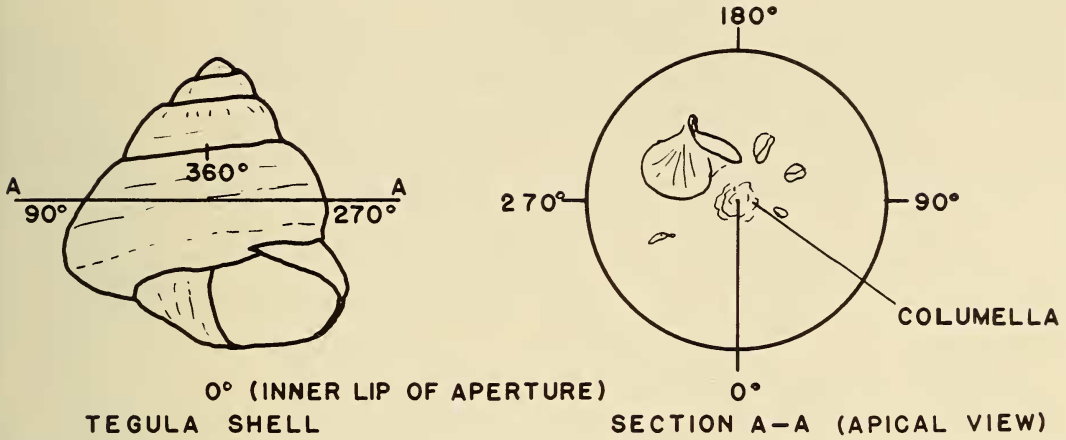

Fig. 2.—Plan of the body whorl of a *Tegula* shell to show the location of burrows of *Trypetesa lateralis*. Barnacles of different ages are shown.

At Haven's Neck, Mendocino County, *P. hemphillii* replaces *P. samuelis* in the higher zones, yielding evidence that the vertical zonation of the barnacle is dependent upon intertidal position rather than upon the species of hermit crab.) Specimens found in shells measuring from 7 to 16 mm in length of aperture; no correlation between size of shell and incidence of barnacles within the size range (over 1,000 shells examined).

Distribution within the shell: Of 1,315 barnacles 98.5 per cent were found in the body whorl with a slightly higher concentration at about 255° from the edge of the aperture (Fig. 2). They burrow on the posterior surface inside the shell (in the "floor" of the shell as viewed with the apex upward). The larvae apparently attach at random, but burrow with the point of attachment away from the columella. They may burrow entirely within the columella.

The flattened mantle is oriented parallel to the surface of the shell with its left side, bearing the external mantle flap, more deeply buried. The ovigerous "disk" extends to the right of the opening in the shell when viewed from the point of attachment (Fig. 1, 2).

Methods.—The study of this barnacle requires certain special methods because of its habit of living inconspicuously on the inside of the shell. The shell has to be broken to check for the presence of the barnacles, which are found to be almost totally confined to the body whorl. They are situated largely on the "floor" of the inside of the shell (with the apex upwards). Thus the tip or apex of the shell can readily be removed with a geologist's pick or chipping hammer without injury to the occupants. It is most satisfactory to remove the apex gently with the hermit crab alive and still in the shell. The crab is then pushed out of the shell with a bent wire or other probe.

If the shells cannot be opened soon after collection, they may be placed in 10 per cent formalin and kept for a short time. After such treatment the crabs may be removed most easily by pulling them bodily from the shell with curved forceps. Detached portions of abdomen may be removed after chipping off the apex of the shell. If the barnacles are to be saved, the crabs should be removed as soon as possible to allow the fixing fluid to penetrate to the barnacles.

The barnacles are located by a "candling" process in which the shell is illuminated from the apertural side by a narrow beam of light and viewed from the removed apical end. The barnacles appear as yellow, orange, or at times reddish areas with a definite outline, the latter depending upon their age. Very small ones appear as slitlike spots of light.

The adult barnacles adhere quite firmly to the shell, in part because they are cemented to it and in part through the action of the "teeth" or "thorns" by which they abrade the shell. The barnacles can be freed from the shell by placing them in a dilute (1 per cent or less) solution of hydrochloric acid in 70 per cent alcohol for a few days. Von Ebner's decalcifying fluid is also satisfactory. In a few days the overlying shell can be carefully picked away and the barnacle lifted out. Bouin's fluid is excellent for removing the larger barnacles in perfect condition, but many of the smaller animals are lost. In using this fixative the shells are covered with fluid

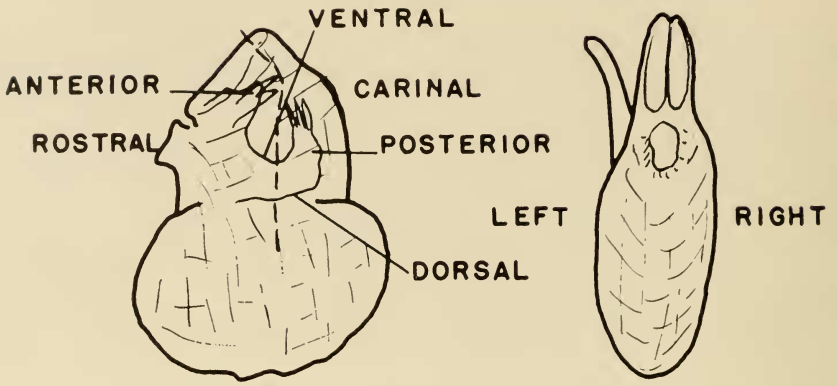

FIG. 3.—The orientation of *Trypetesa lateralis*.

until they are quite soft, which may require several changes of fluid. Jeweler's forceps are valuable in removing the smaller barnacles.

The collecting of the shells in the field was done under varying conditions of tide level and of depth at which the crabs were found. All

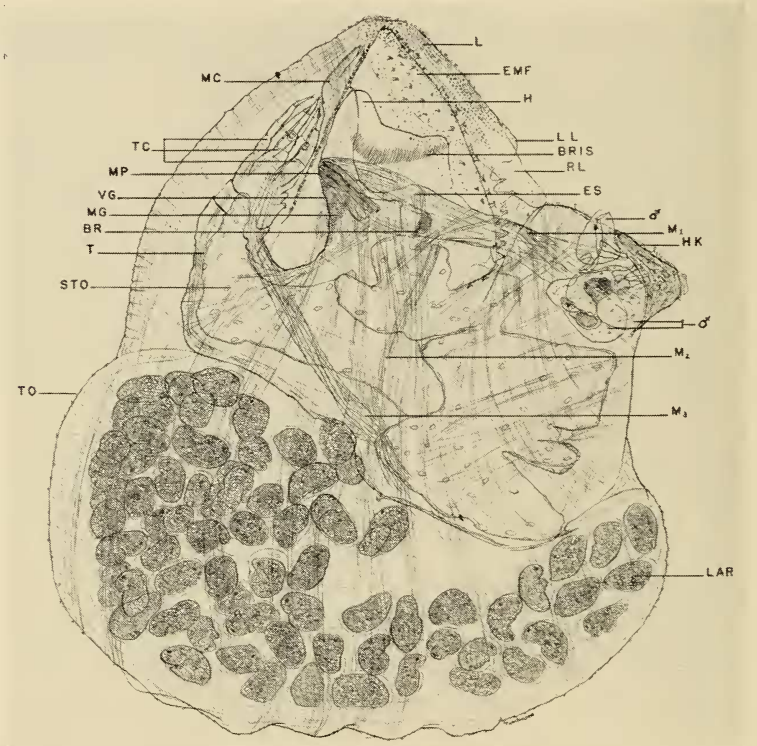

FIG. 4.—*Trypetesa lateralis*, n. sp. A mature female with three males attached. Left lateral view. Camera lucida drawing, × 92.

ABBREVIATIONS USED IN FIG. 4.

BR—Brain.
BRIS—Bristles on the side of the head.
EMF—External mantle flap.
ES—Esophagus.
H—Head.
HK—Horny knob.
L—Lip of the mantle.
LAR—Larva.
LL—Left lip.
LMF—Left internal mantle flap.
$M^{1,2,3}$—Muscles (numbered).
MC—Mouth cirrus.
MG—Maxillary gland.
MP—Mouth parts.
RL—Right lip.
STO—Stomach.
T—Thorax
TC—Thoracic cirri.
TO—Tooth.
VG—Ventral ganglion.
♂—Males.

hermit crabs were collected at random, with no selection for crab or shell types. The differences in the composition of these collections may be seen in Table 1.

Several hundred living *Tegula brunnea* and *T. funebralis* were collected at Moss Beach, San Mateo County, and inspected for specimens of *Trypetesa*, but none were found. Likewise examination of several hundred *Mytilus californianus* shells, living and dead, and of several specimens of large balanoid barnacles from the Monterey Peninsula revealed no *Trypetesa*.

The life cycle.—An analysis of the numbers and sizes of *Trypetesa lateralis* from collections at Moss Beach, San Mateo County, at different times of the year has been made to determine the life cycle. The percentage infection of shells, the average number of barnacles per infected shell, the percentage of larvae in the population, and the average size of the barnacles has been plotted (Fig. 6). Larval-sized barnacles have a slit length of 0.25 mm; when the barnacle starts to mature the slit rapidly becomes longer.

The results seem to indicate that the period of greatest larval settling is during the months of November, December, and January, and again to a lesser degree in June. An increase in the numbers of barnacles per infected shell and the percentage of larvae, with a concommitant decrease in the average barnacle size, give evidence for this larval settling. The drop in the percentage infestation of shells may indicate the breakdown of older shells with larger barnacles, resulting in a decrease in the average size and the increase in the percentage of larva. In the latter case the number of barnacles per infected shell should not increase, which it does. This increase favors the argument for the actual influx of larvae rather than the breakdown of shells.

The recruitment of young barnacles must be very rapid, for during the period of study the percentage of larval-sized barnacles did not fall below 50 per cent. This would imply a very high mortality of barnacles in proportion to the rate of growth. The data are not adequate for a determination of this factor. The life cycle of this barnacle is intimately associated with the length of time that the host shell remains intact. Information on this subject would be of great interest.

The growth of the females of *Trypetesa lateralis* is accompanied by molts, but distinct molt stages or instars are not evident from available data. The results of measurements of 152 barnacles along two axes have been plotted (Fig. 7). The diameter of the lips and disk was

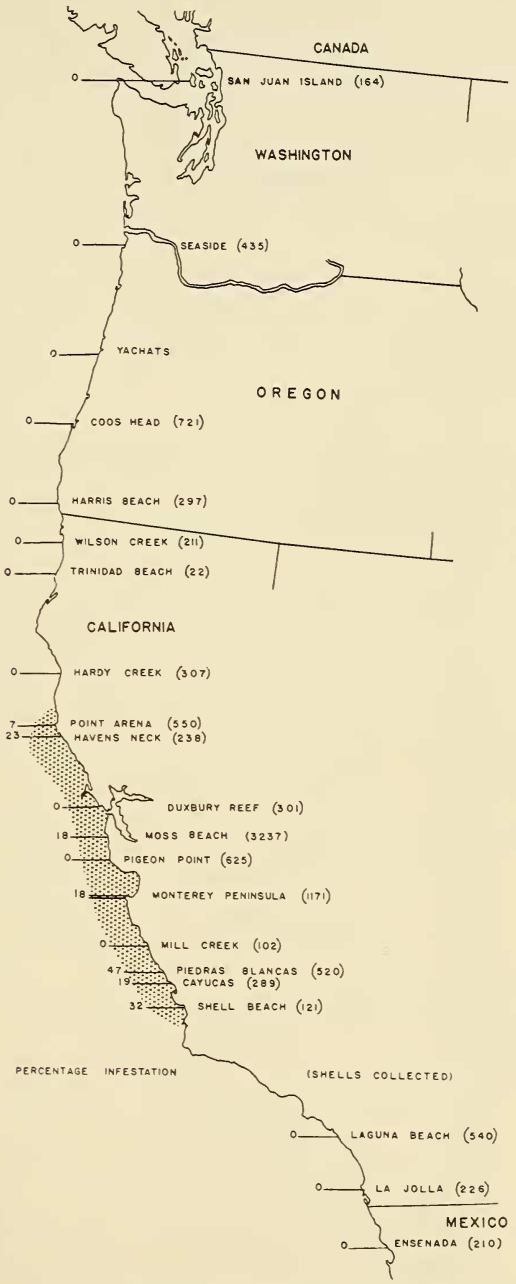

Fig. 5.—Distribution of *Trypetesa lateralis* in the western United States littoral. The shaded area indicates the range. The figures at the left indicate the percentage of infestation, while the figures in parentheses at the right denote the number of shell specimens collected. The double line at the Monterey Peninsula indicates extensive collections at several points.

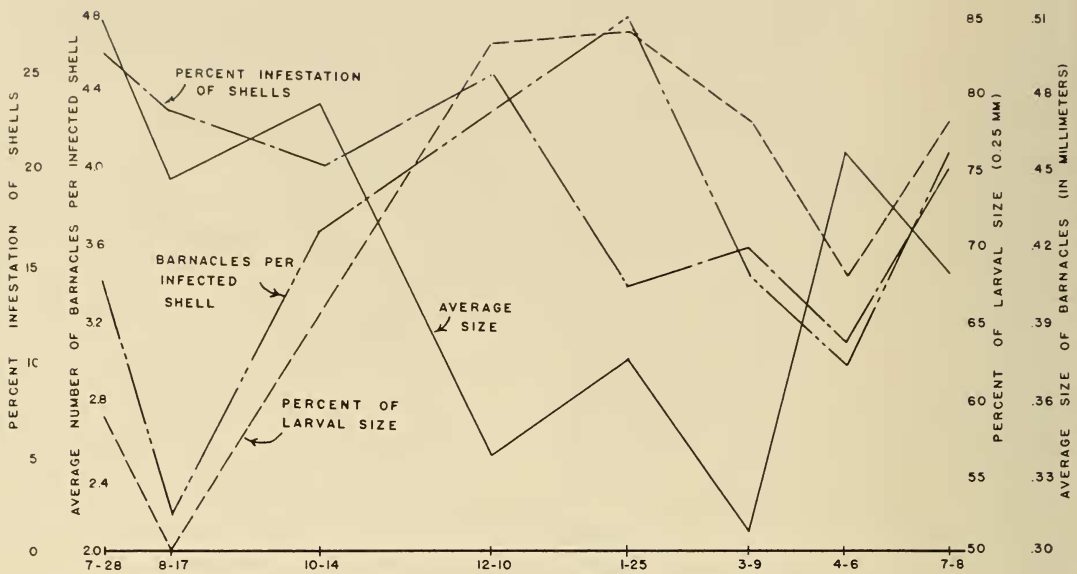

FIG. 6.—Analysis of barnacle numbers and sizes at Moss Beach at different times of the year. The *per cent larval size* is the percentage of the total barnacle sample which was of larval size, or 0.25 mm in slit length. The numbers on the abscissa indicate the month and day, 1951 to 1952.

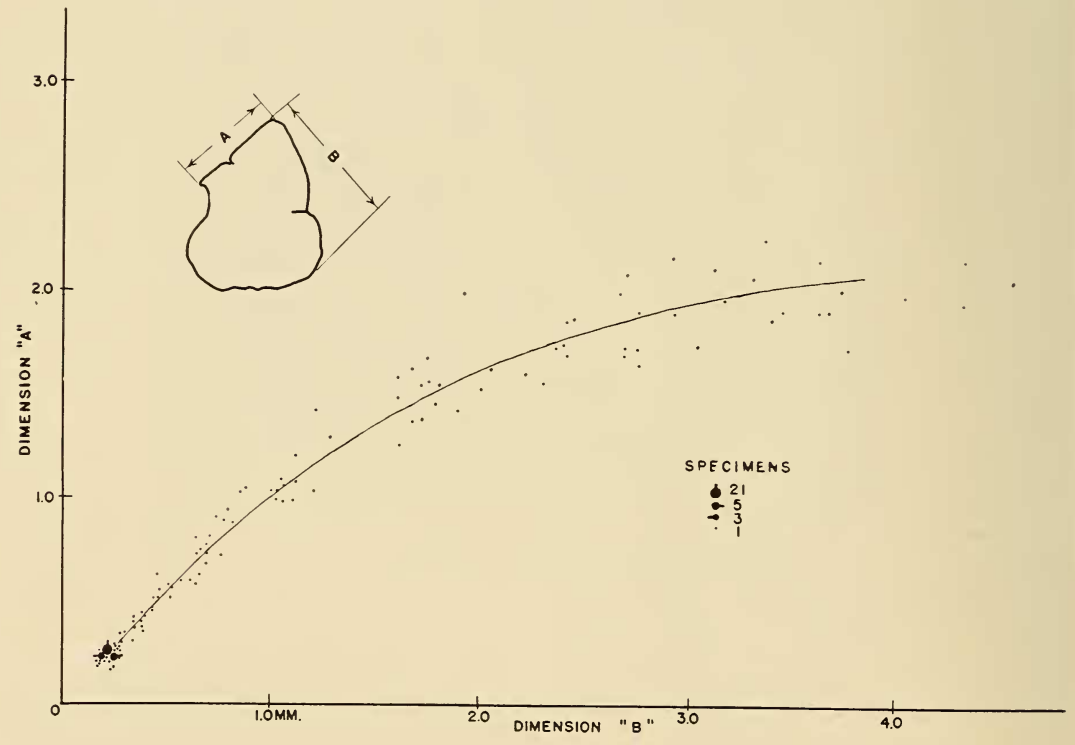

FIG. 7.—Bidimensional growth. A growth curve obtained by plotting lengths "A" and "B" on 2 axes. In all, 152 specimens (a mixed sample) were measured. Different areas, plotted separately, did not give a significant difference.

measured from the distal (carinal) notch of the mantle slit to the furthest corner of the horny knob (dimension "A"). The body diameter was measured perpendicular to the plane of the outside edge of the lip and knob to the opposite edge of the reproductive fan at the widest point (dimension "B"). The growth curve obtained by plotting these two measurements shows that the slit (dimension "A") grows rapidly at first during the juvenile stage, while the reproductive fan (dimension "B") grows markedly during adulthood. No grouping of the results is obtained, however, to warrant the designation of larval instars.

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TABLE 1.—ANALYSIS OF INFECTED AREAS

	Tegula funebralis Total shells	With barnacles	Per cent infected	*Tegula brunnea* Total shells	With barnacles	Per cent infected	Miscellaneous shells	With barnacles	Per cent infected	Total shells	Total shells with barnacles	Total per cent infected
Point Arena 2/24/52												
gran	162	3	2	49	7	14	6	0	0	217	10	5
hemp	3	0	0	8	2	25	0	0	0	11	2	18
hirs	56	4	7	8	0	0	2	0	0	66	4	6
sam	230	12	5	6	3	50	6	0	0	242	15	6
unkn	11	0	0	3	2	67	0	0	0	14	2	14
	462	19	14	74	14	19	14	0	0	550	33	6
Havens Neck 8/7/51												
gran	67	0	0	11	6	55	1	0	0	73	6	8
hemp	30	5	17	64	34	58	0	0	0	94	42	45
sam	38	2	5	3	0	0	2	0	0	43	2	5
unkn	14	0	0	12	3	25	2	0	0	28	3	11
	143	7	5	90	43	48	5	0	0	238	53	22
Moss Beach												
7/28/51	58	15	26	116	30	26	0	0	0	174	45	26
8/17 *Low* gran	4	0	0	98	18	18	0	0	0	102	18	57
rest	2	0	0	17	7	41	0	0	0	19	7	37
	6	0	0	115	25	22	0	0	0	121	25	21
High gran	1	0	0	18	3	17	0	0	0	19	3	16
sam	41	5	12	97	32	33	0	0	0	138	37	27
	42	5	12	115	35	30	0	0	0	157	40	25
Total	48	5	10	230	60	26	0	0	0	278	65	23
10/14/51	126	26	21	412	80	19	2	0	0	540	106	20
12/10 *Low*	10	0	0	239	56	24	2	0	0	251	56	22
High	27	4	15	167	52	31	0	0	0	194	56	29
	37	4	11	406	108	27	2	0	0	445	112	25

TABLE 1—*Continued*

	Tegula funebralis Total shells	With barnacles	Per cent injected	*Tegula brunnea* Total shells	With barnacles	Per cent infected	Miscellaneous shells	With barnacles	Per cent infected	Total shells	Total shells with barnacles	Total per cent infected
1/25/52 gran	14	0	0	401	52	13	3	1	33	418	53	13
sam	10	1	10	15	4	27	0	0	0	25	5	20
unkn	3	0	0	20	7	35	0	0	0	23	7	30
	27	1	37	436	63	14	3	1	33	466	65	14
3/9	104	16	15	485	78	16	4	0	0	593	94	16
4/6	99	12	12	382	41	11	5	0	0	486	53	11
7/8	120	23	19	135	29	21	0	0	0	255	52	20
Total	619	102	16	2602	489	19	16	1	6	3237	592	18
Monterey County, July 1951												
Point Pinos	528	90	17	127	20	16	1	0	0	656	110	17
Point Joe	27	8	30	40	10	25	0	0	0	67	18	27
Fan Shell Beach	26	9	35	20	7	35	1	0	0	47	16	34
Pescadero Point	18	0	0	12	3	25	2	2	100	32	5	16
Mission Point	25	1	4	5	0	0	0	0	0	30	1	3
	624	108	17	204	40	20	4	2	50	832	150	18
Piedras Blancas 8/5/51												
gran	131	23	18	162	97	60	1	0	0	294	120	41
sam	168	80	48	58	47	81	0	0	0	226	127	56
unkn	10	6	60	9	4	44	0	0	0	19	10	53
	309	109	35	229	148	65	1	0	0	539	257	48
Cayucas 9/16/51												
	278	54	19	9	0	0	2	0	0	289	54	19
Shell Beach 8/6/51												
gran	45	7	16	5	2	40	3	1	33	53	10	19
sam	60	28	47	6	2	33	2	0	0	68	30	44
	105	35	33	11	4	36	5	1	20	121	40	33
Total	1875	387	21	2278	608	27	24	4	17	4177	999	24.0

ABBREVIATIONS USED IN TABLE 1

ber—Pagurus beringanus.
gran—P. granosimanus.
hemp—P. hemphillii.
hirs—P. hirsutiusculus.
sam—P. samuelis.
unkn—Unknown.
* —Whelk type of shell.
† —Tegula ligulata.

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ZOOLOGY.—Polydora nuchalis, *a new species of polychaetous annelid from California.*[1]

KEITH H. WOODWICK, Allan Hancock Foundation, University of Southern California. (Communicated by Waldo L. Schmitt.)

The spionid worm described herein is the tenth species of *Polydora* to be reported from California (for others see Hartman, 1941). Although resembling several other species in some characteristics, the worm is clearly and consistently different; it is therefore described as a new species.

Polydora nuchalis, n. sp.

The body is generally depressed; it is most so at the modified fifth segment where it is more than twice as wide as deep. It is less depressed in front of and behind this segment. The body tapers posteriorly just before the terminal flaring pygidium. The range observed in the number of segments is 80 to 110; in millimeters of length 15 to 20. In life this polydorid is translucent yellow in color, some individuals having a smoky surface pigmentation in the anterior two-thirds of the body and in the pygidial region. The palpi lack pigment granules but are colored bright red by the blood as are the middorsal and midventral lines and the branchiae of living specimens.

The prostomium is bifid anteriorly and extends posteriorly as the caruncle to the forward margin of the third setigerous segment [third segment below] (Fig. 1, b). A median nuchal tentacle, on which the specific name is based, arises from the prostomium at the level of the first segment. Two pairs of eye spots in a trapezoidal arrangement are found near the palpal bases. The posterior ones are closer together and slightly smaller than the anterior pair. The palpi are long and extend back to the twentieth segment in preserved specimens. The peristomium flares to each side of the prostomium; it is bounded above by the latter and in front and ventrally by the oral aperture.

The first segment lacks notosetae; the parapodia are represented by notopodial and neuropodial lobes and a neuropodial fascicle of setae (Fig. 1, a). The neuropodial lobe and setae are oriented on a line with the notopodial lobes of the succeeding segments. The short, first notopodial lobes are located dorsally just behind the palpal bases.

The next three segments have well-developed notopodial and neuropodial postsetal lobes and fascicles of long slender setae. The notopodial fascicle has two rows of setae including an anterior row of short limbate and a posterior one of longer capillary setae. This notopodial arrangement continues through segments 6 to 9. The neuropodia of segments 2 to 4 have capillary setae.

Segment 5 (Fig. 1, a) is larger than either the fourth or the sixth segment; it lacks postsetal lobes. Its notopodium has a bundle of anterior dorsal capillary setae and a slightly curved single series of large spines alternating with as many companion setae. The spines are largest anterodorsally and are gradually reduced in size posteriorly. They are weakly falcate in shape (Fig. 1, d); the companion setae are

[1] Contribution no. 119 from the Allan Hancock Foundation, University of Southern California, Los Angeles, Calif. This study was aided by the personnel and made possible through the use of the facilities of the Allan Hancock Foundation.